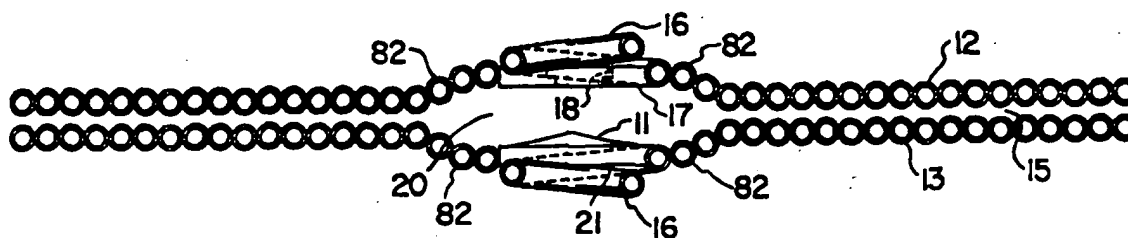


INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/CA96/00136</p> <p>(22) International Filing Date: 5 March 1996 (05.03.96)</p> <p>(30) Priority Data: 08/563,917 29 November 1995 (29.11.95) US</p> <p>(71) Applicant: POWERTECH INDUSTRIES INC. [CA/CA]; 660 - 688 West Hastings Street, Vancouver, British Columbia V6B 1P1 (CA).</p> <p>(72) Inventor: MOVASSAGHI, Mehrzad; 2316 West 13th Avenue, Vancouver, British Columbia V6K 2S6 (CA).</p> <p>(74) Agent: VERMETTE, Clifford, W.; Vermette & Co., Box 40, Granville Square, Suite 230 - 200 Granville Street, Vancouver, British Columbia V6C 1S4 (CA).</p>	<p>(81) Designated States: AM, AT, AU (Petty patent), BB, BG, BR, BY, CA, CH, CN, CZ, DE, DE (Utility model), DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, UG, UZ, VN.</p> <p>Published <i>With international search report.</i></p>	

(54) Title: PULSE COMBUSTOR AND BOILER FOR SAME



(57) Abstract

A pulse combustor of a type having a combustion chamber (20) in the center between two spaced apart walls (12, 13) and an exhaust region (15) between the plates which surrounds the combustion chamber and extends outwardly therefrom. The combustor has first (12) and second (13) spaced apart walls each formed of hollow tubing wound in a spiral from the combustion chamber outwardly, and a fuel inlet in the combustion chamber. An ignition rod has an electrode which extends into a nozzle at an entrance of a combustion chamber proximate an incoming fuel passageway and initially ignites the fuel therein in order to start the combustor.

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PULSE COMBUSTOR AND BOILER FOR SAME

FIELD

The present invention relates to a pulse
5 combustor and a boiler which employs the pulse combustor.

BACKGROUND

A pulse combustor is a device in which a mixture
of air and fuel is initially ignited by, for example, a
10 ignition rod. The ignited gases expand rapidly with an
associated rapid increase in pressure and temperature. A
resultant pressure wave travels down the device expelling
the burnt gases out of an exhaust region. Heat exchange
occurs at the walls of the device cooling the gases and
15 enhancing the pressure drop occurring after passage of the
pressure wave. This pressure drop due to expansion of the
gases combined with the cooling caused by heat exchange at
the walls causes new gases to be drawn into the combustion
chamber. At the same time the flow in the exhaust region
20 reverses and compresses the new air and gas mixture and
with the temperature in the combustion chamber still being
high ignition occurs once again.

U.S. Patent No. 4,968,244 issued to the Inventor
25 herein, Mehrzad Movassaghi, describes a pulse combustor
with a radial exhaust chamber and a carburetor coupled to
the combustion chamber for injecting a pre-determined
distribution of fuel mixture into the combustion chamber.
The design of the casing of the exhaust chamber comprises
30 an inside disc and an outside disc juxtaposed thereto with
an inside disc and outside disc located on each side of the
combustion chamber. The exhaust chamber has a spiral
groove in the inside disc which is covered by the outside
plate forming a coolant passageway. The usage of a disc
35 and plate bonded together with a spiral groove in the disc
makes construction difficult and expensive. Moreover, the
rapid heating and cooling stresses the bonding between the
disc and plate making the device susceptible to coolant

leaks. Finally, the somewhat complex design of the carburetor adds to the expense of the device.

5 In any known heat generation system used in either a boiler or furnace, control is achieved by turning the heat generating system on and off. When the temperature exceeds a preset threshold, the system is turned off and allowed to cool. Similarly, once cooling has lowered the temperature below a threshold, the system is restarted. Obviously, heating above the threshold on heating up and cooling below the threshold on cooling down are inherent in such a control system. The constant cycling between the temperatures at shut-off and turn-on contribute to high thermal stresses which reduce the life expectancy of the material.

Accordingly, it is an object of the invention to provide a less costly, more efficient and reliable radial pulse combustor than is presently known. It is a further object of the invention to provide a boiler which utilizes the aforesaid pulse combustor and in which control of the output temperature is applied continuously.

SUMMARY OF THE INVENTION

25 According to the invention there is provided a pulse combustor having a central combustion chamber surrounded by an exhaust chamber, wherein a portion of the combustion and exhaust chambers are formed between two spaced apart walls of spiral wound coolant tubing. The coolant tubing which forms the walls provides much greater heat transfer area while at the same time considerably simplifying the construction of the combustor. In order for there to be a coolant leak in such a design, there would have to be a perforation in the tube itself. A fuel nozzle is located at an inlet to the combustion chamber and a spark generator is provided in the combustion chamber and proximate the nozzle in order to ignite the fuel entering the pulse combustor upon startup.

Preferably, the pulse combustor has a radial design with a circular combustion chamber and circular tail pipe region surrounding the combustion chamber. However, other shapes could be used such as a generally rectangular combustion chamber with rounded edges and a similar shape for the tail pipe region surrounding the combustion chamber. Adjacent tubes are welded so that there is no leakage of exhaust gases between the tubes.

Advantageously, a control system supplies a preset air/gas mixture to the combustion chamber. The system includes a variable speed fan which controls air flow and a gas mass flow regulator which maintains the ratio of air to gas going to the combustion chamber constant. A single temperature threshold is established such that when the temperature of the coolant exiting from the boiler approaches the threshold, the fan speed is reduced causing the gas mass regulator to reduce the flow of gas so that the flow of the air/gas mixture into the combustion chamber is reduced, thereby lowering the energy output of combustion. Thus, the pulse combustor does not normally shut off but merely operates with a controlled mass of gas and air mixture.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as other features and advantages thereof, will be best understood by reference to the detailed description which follows, read in conjunction with the accompanying drawings, wherein:

FIG. 1 is a front elevation view of the radial pulse combustor;

FIG. 2 is an elevation view of the radial pulse combustor showing the inlet and outlet coolant tubes;

FIG. 3 is an elevation view of the radial pulse combustor showing the inlet coolant tubes;

5 FIG. 4 is a section view of the pulse combustor in elevation showing the spacing between the walls of tubing;

10 FIG. 5 is an elevation view in section of the nozzle;

FIG. 6 is an end view of the nozzle;

15 FIG. 7 is a front elevation view of a boiler assembly which incorporates the combustor with the front panel removed;

20 FIG. 8 is perspective view of the boiler showing coolant inlets and outlets and the fan;

FIG. 9 is a second perspective of the boiler showing the mass flow regulator and the connection into the combustion chamber of the radial pulse combustor;

25 FIG. 10 is a schematic diagram showing the boiler control system; and

FIG. 11 is an elevation view of the nozzle assembly.

30

DETAILED DESCRIPTION WITH REFERENCE TO THE DRAWINGS

Referring to FIGS. 1 to 4 there is shown the radial pulse combustor 10 which is formed by a pair of spaced apart walls 12 and 13 with each wall made of spiral coolant tubing spiraling outwardly from a central outlet tube 16 to an outer inlet tube 14. The coolant tubing is stainless steel. The walls 12 and 13 are welded to two central plates 17 and 21. A gas nozzle receptacle 18 is

formed through the center of a circular plate 17 (see also FIG. 4) fitted into the center of wall 12 into a combustion chamber 20 bounded by plates 17 and 20 and a conical portion 82 of walls 12 and 13. Tabs 69 welded to the perimeter of each wall 12 and 13 of tubing to provide a means of mounting the combustor 10 and for spacing apart the walls 12 and 13 a predetermined distance. Between each set of tabs 69 there is inserted a spacer (not shown) which provides the required gap between the plates 12 and 13. An interior surface of plate 21 has a conical surface 11 that faces nozzle receptacle 18. Conical surface 11 disperses the flame outwardly through the combustion chamber 20. The volume 15 between the walls 12 and 13 is termed the tail pipe. Water enters each tube 14 of walls 12 and 13 at the perimeter and exits at the center through tube 16 to allow for a counter flow heat exchange process.

Shut off valves 22 and 22a allow manual closure of the flow into and out of the cooling tubing 14. The diameter of the combustor 10 is approximately 44.5 inches and is chosen so that the rarefaction waves that reach the perimeter of the tail pipe region 15 and return to the combustion chamber 20, reach the combustion chamber 20 at the precise time at which a new charge of air/gas mixture is drawn into the combustion chamber 20. The separation of the walls 12 and 13 is approximately 0.4 inches while in the combustion chamber 20 the sides are inclined at about 25 degrees to a plane passing through the tail pipe region parallel to the walls 12 and 13. The width of the combustion chamber 20 is approximately 2.34 inches while its diameter is approximately 12.5 inches.

Referring to FIGS. 5, 6, 8 and 11, the nozzle 19 has a lower portion 54 of reduced diameter which fits into a lower portion of receptacle 18. The nozzle interior has threads 28 at one end which register with the threads (not shown) of a male end of a reducer pipe 61 (see FIG. 11). Pipe 61 couples the nozzle 19 to a pipe 31. A threaded end

cap 83 having a threaded opening to register with the threads of ignition rod 32 align the ignition rod 32 with the nozzle 19. A long insulating rod 26 extends from and forms a part of the ignition rod 32 into the nozzle 19.

5 From the end of rod 26 an electrode 33 protrudes and is bent over into a hook shape at its end with its point flush with one of several radially spaced injection holes 35 that terminate in recess 24 to produce immediate combustion of the air/gas mixture. An annular interior

10 projection 45 (see FIG. 5) is angled towards the end of nozzle 19.

Referring to FIG. 7, the pulse combustor 10 is mounted inside a casing 30 with its water outlet tubes 16

15 passing through a top panel 36 of casing 30. Nuts and bolts (not shown) pass through brackets 86 on the front and rear of casing 30 and through the tabs 69 and spacers (not shown). Referring to FIGS. 8 and 9, pipe 48 couples an outlet 53 from fan 40 to a T-section of pipe 49. Pipe 49,

20 in turn, connects to pipe 31. Mixing of gas and air takes place in pipe 49. A gas mass flow regulator 44 and gas shut-off valve 52 are located between a gas line 42 coupled to a gas supply line (not shown) and a gas pipe 59. Pipe 59 couples to coupling 55 which, in turn,

25 connects to pipe 46. Pipe 46 connects to T-section of pipe 49. Flow sensors 58 monitor the flow of coolant through the tubing of each wall 12 and 13.

At the top of the casing 30, coolant lines 23

30 and 25 connect to respective outlet tubes 16 of the pulse combustor 10 while coolant lines 27 and 29 connect to respective inlet lines 14. A high limit temperature switch 39 is coupled to a manifold 34. Manifold 34 interconnects coolant lines 23 and 25. A thermocouple 62

35 is coupled to manifold 34 to measure the temperature of coolant after it has passed through the combustor 10. Flow sensors 56 and 58 are coupled to the inlet to coolant lines 27 and 29, respectively, and sense the flow of

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coolant into coolant lines 27 and 29 from manifold 36. A controller 50 (see FIG. 10), housed within electrical box 87, is coupled to the fan 40, the ignition rod 32, and various relays and switches and controls the operation of the system. A duct 47 (see FIG. 8) is provided at the center of the rear panel to allow for the exit of combustion products from the casing 30.

Referring to FIG. 10, the complete boiler control system includes fan 40 which has an outlet 53 coupled to pipe 48 in which there is located an orifice 51 that enhances the mixing of air with gas. Pressure is sensed at A1 on the upstream side of orifice 51 and on A2 which is on the downstream side of orifice 51. A second orifice in connector 55 located on the gas line 59 connected to the outlet from the gas mass flow regulator 44 causes a build up of pressure in the gas line 59 after which gas enters pipe 46. Pressure is sensed at G1 before the second orifice in connector 55 and G2 after the second orifice. The pressure at the points A1, A2, G1 and G2 are continuously measured by the mass flow regulator and based upon the differentials A1-A2 and G1-G2, the flow of gas through the regulator is automatically adjusted for the appropriate air/gas ratio in the mixing chamber inside T section 49.

A flame probe 41 is located so that its sensor is inside the combustion chamber 20 and is coupled by wire 37 to controller 50. Flame probe 41 senses the presence of flame in the pulse combustor 10 and sends a signal along wire 37 to advise the controller 50 of this fact.

Controller 50 connects through an air differential switch 68, a water flow switch 70 and a high temperature limit switch 39 to a contact of relay 80. The other terminal of the contact of relay 80 is connected to one output of a transformer 76 coupled to line voltage. The other output terminal of transformer 76 is coupled

through thermostat 74 to the controller 50. A speed control 60 is coupled to fan 40, across another contact of relay 80, to an output of a temperature setpoint control 64 and to line voltage. Temperature setpoint control 64 is connected to timer relay 66 and to thermocouple 62 which senses the temperature of outlet coolant from the combustor 10. Transformer 76 steps down line voltage to 24 VAC. The other end of the latter contact of relay 43 connects to the other solenoid terminal of the gas valve 52. One contact of the secondary of transformer 76 connects to timer relay 66 while the other terminal connects directly to relay 43. Thus, when relay 43 is activated and its contacts closed, the output of transformer 76 is applied timer relay 66. Prior to timing out, the output of timer relay 66 as sensed on lines 57 by temperature setpoint control 64 causes the fan 40 to operate on a low flow basis.

An air gas mixture entering the combustion chamber 20 through the nozzle 19 is ignited by a spark from an end of electrode 33. The resulting explosion of the air/gas mixture causes a sudden rise in the pressure of the combustion chamber 20, thus generating pressure waves which expand radially outward towards the perimeter of the coils. This rapid expansion of the gases, together with cooling by means of heat exchange with the walls 12 and 13 through the flow of water, causes a negative pressure (below atmospheric pressure) inside the combustion chamber 20. At the same time, the pressure waves carrying the combustion products, come to an instantaneous rest at the perimeter of the coils, reverse in direction and travel radially inward, in the form of rarefaction waves, towards the combustion chamber. These rarefaction waves pre-compress the new volume of air and gas; the temperature in the combustion chamber 20 still being high, the new air/gas volume is combusted without the need for ignition from the electrode 33, and the process is repeated.

On start-up water flow into each of the tubes of walls 12 and 13 is initiated by first closing shut off valve 22 and opening shut off valve 22a so that coolant is forced to travel through one wall of walls 12 and 13 only, and then opening valve 22 to force coolant through the other of walls 12 and 13. This procedure ensures that there is flow in each wall of the combustor 10.

Once water is flowing, the power switch 88 is turned on. Thermostat 74 will then call for heat. Terminals 4 and 5 on the sequencer 80 will close and the fan 40 will start. After 45 seconds terminals 1 and 3 on the sequencer 80 close and 24 volts is supplied to the ignition controller 50 through the high temperature limit switch 39, the water flow switch 70, and the air differential switch 68. The water flow switch 70 is normally open. As soon as water flows through both coils it closes. Similarly, the air differential switch is normally open but as soon as the fan 40 comes on, the air differential switch closes. The high temperature limit switch is normally closed. As soon as the water temperature rises above that set by the end user, this switch opens and terminates the combustion thereby shutting down the boiler.

The ignition controller 50 sends 25,000 volts to the electrode 33 and 24 volts to the solenoid valve 52 through relay 43 which turns on the gas flow at the same time as the electrode 33 is energized. Gas flows to the mass flow regulator 44 through the now open solenoid valve 52. From the regulator 44, gas flows into the mixing chamber inside T-section 49. The mixture enters the nozzle 19 and combustion chamber 20 where combustion takes place. Upon ignition, the spark will be stopped 2 seconds after the flame is sensed by the flame sensor 41. Signals from the flame sensor 41 are sent to the ignition controller 50 and the solenoid valve 52 remains open as long as these signals are received.

At the start of each operation, the timer 66 relay will be at set point corresponding to a frequency of 40 Hz applied to the fan 40. After 30 seconds the set point will move to that corresponding to a frequency of 65 Hz. When the ignition controller 50 is energized the following sequence of events takes place. Terminals 3 and 5 and 6 and 4 on relay 43 close, thus applying power to the timer relay 66. For the first 30 seconds, the timer relay 66 will be at set point 40 Hz after which it moves to 65 Hz. Thermocouple 62 continuously measures the water temperature at the boiler outlet and these signals are sent to controller 64. If the temperature measured by thermocouple 62 is below that of controller 64, corresponding signals are sent to the speed controller 60 which controls the fan speed. The fan 40 is the operates at a high speed. If the temperature measured by thermocouple 62 approaches that measured by the temperature setpoint control 64, corresponding signals are sent to the speed control 60 and the fan will speed will reduce correspondingly. Through sensing the A1-A2/G1-G2 ratio, a drop in A1-A2 results in the gas mass regulator reducing the gas flow. A reduction in gas flow causes a reduction in G1-G2 so the ratio A1-A2/G1-G2 remains constant. Thus the throttle system allows for optimum continuous operation of the boiler, significantly reducing the on/off cycles.

Should the spark fail to ignite the pulse combustor 10 as detected by the flame probe 41 within 5 seconds, the entire system is shut down with the gas valve 52 closing and the sensors being deactivated.

One example of a use for the present boiler system is to supply hot water to a hot water tank. The thermostat 74 would be used to measure the temperature of the water in the tank (not shown). Once the temperature of water in the tank fell below a preset limit, the thermostat 74 would close and the system would initiate startup and

then full operation. Thermocouple 62 would sense the temperature of the water being supplied to the tank by the boiler system. The boiler system would then supply water at the temperature established by the temperature setpoint control 64.

Accordingly, while this invention has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications of the illustrative embodiments, as well as other embodiments of the invention, will be apparent to persons skilled in the art upon reference to this description. It is therefore contemplated that the appended claims will cover any such modifications or embodiments as fall within the true scope of the invention.

I CLAIM:

1. A pulse combustor of a type having a combustion chamber in the center between first and second spaced apart walls and a tail pipe region between the plates which surrounds the combustion chamber and extends outwardly therefrom, comprising said first and second spaced apart walls each formed of hollow tubing wound in a spiral from the combustion chamber outwardly with the adjacent windings being contiguous, a fuel nozzle coupled to an inlet of said combustion chamber, and a spark generator in said combustion chamber located proximate said nozzle so as to ignite incoming fuel on startup, and wherein said tubing of each of said walls is adapted to conduct coolant.
2. A pulse combustor according to claim 1, wherein heat exchange coolant enters tubing of said first and second walls at the periphery thereof and exits from tubing leaving proximate said combustion chamber.
3. A pulse combustor according to claim 1, wherein adjacent windings of said tubing are welded together so that gas cannot leak out of said tail pipe region.
4. A pulse combustor according to claim 1, wherein said nozzle has a plurality of fuel passageways radially spaced around an axis thereof for conducting fuel therethrough and said spark generating means is an ignition rod having a central insulating rod extending into said nozzle and enclosing a central electrode extending out of an end of said insulating rod and which curves back so that its tip is proximate an exit of one of said fuel passageways.
5. A pulse combustor according to claim 1, wherein said walls are substantially circular.

6. A boiler having a coolant temperature control system which operates substantially continuously, comprising:

(a) a combustor for combusting an air/gas fuel mixture;

(b) a fan for providing a flow of air in an air line leading to said combustor;

(c) a speed control unit coupled to said fan and operative to control the speed thereof in response to a coolant temperature control signal;

(d) a gas line coupled to a source of gas;

(e) means for reducing the gas flow in response to a reduction of the air flow;

(f) means for mixing air from said air line with gas from said gas line and for directing the mixture to said combustor;

(g) heat exchange lines passing over said combustor to conduct coolant which absorbs heat from combustion therein; and

(h) a temperature sensor for measuring the temperature of coolant after passing through said combustor and transmitting the temperature measurement to said speed control unit,

wherein said speed control unit slows down the speed of said fan when the coolant temperature approaches a preset limit.

7. A boiler according to claim 6, wherein said means for reducing the gas flow includes:

(a) means for measuring a pressure differential in each of said gas and an air lines; and

(b) a gas mass flow regulator in said gas line operative to control the flow of gas depending upon the ratio of the differential pressure measurements in said air line to that in said gas line so that as the flow of air is reduced so is the flow of gas.

8. A boiler according to claim 6, wherein said temperature sensor is a thermocouple coupled to the coolant exiting from said combustor.

9. A boiler according to claim 6, including means for purging said combustor of spent exhaust gases prior to ignition.

10. A boiler according to claim 6, including an orifice in each of said air and gas lines and pressure sensing lines on each side of each of said orifices to detect the pressure and transmit it to said gas mass flow regulator.

11. A boiler according to claim 6, wherein said combustor is of a type having a combustion chamber in the center between first and second spaced apart walls and a tail pipe region surrounding said combustion chamber also between said walls surrounding said combustion chamber and extending outwardly therefrom.

12. A boiler according to claim 10, wherein said first and second spaced apart walls are each formed of hollow tubing wound in a spiral from the combustion chamber outwardly with the adjacent windings being contiguous, a fuel nozzle coupled to an inlet of said combustion chamber, and spark generating means in said combustion chamber located proximate said nozzle so as to ignite incoming fuel

on startup, and wherein said tubing of each of said first and second walls conducts coolant.

13. A pulse combustor according to claim 11, wherein heat exchange coolant enters said tubing of said first and second walls at the periphery thereof and exits from tubing leaving proximate said combustion chamber.

14. A pulse combustor according to claim 11, wherein adjacent windings of said tubing are welded together so that gas cannot leak out of said exhaust region.

15. A pulse combustor according to claim 11, wherein said nozzle has a plurality of fuel passageways radially spaced around the axis thereof for conducting fuel therethrough and said spark generating means is an ignition rod having a central insulating rod extending through said nozzle and enclosing an electrode which extends out from an end of said insulating rod and curves back so that its tip is proximate one of said gas passageways.

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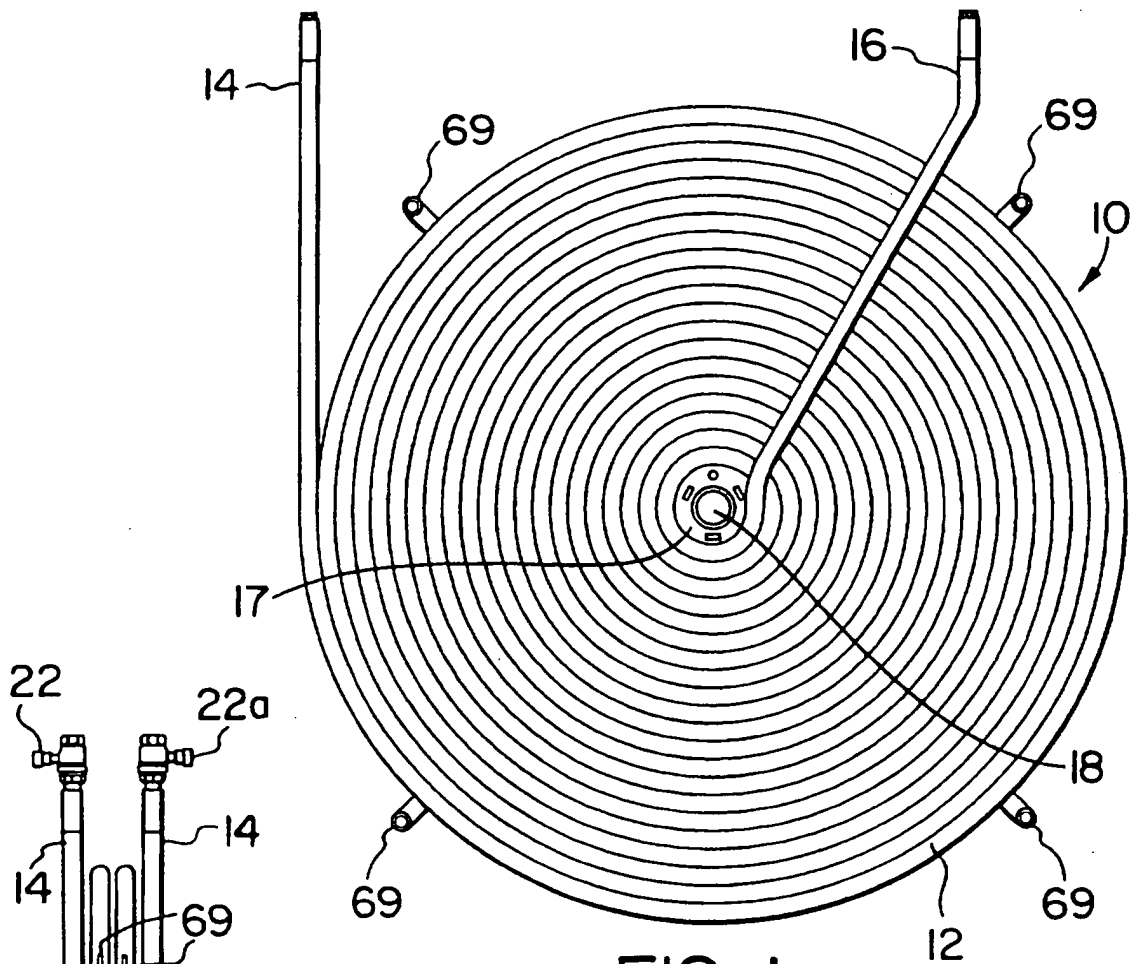


FIG. 1

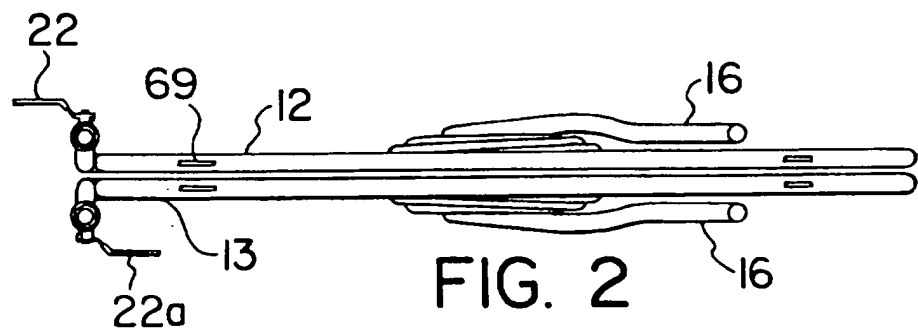


FIG. 2

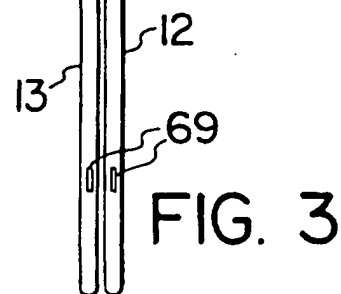


FIG. 3

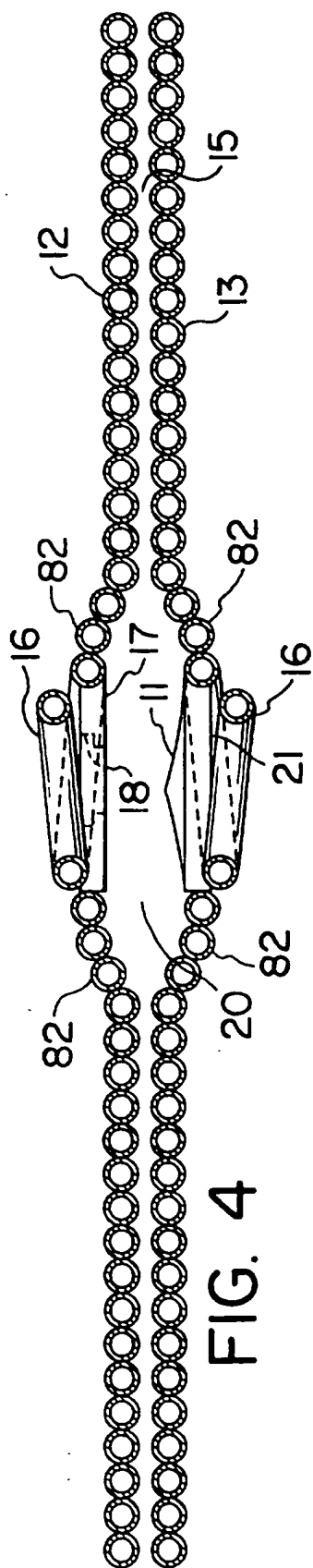


FIG. 4

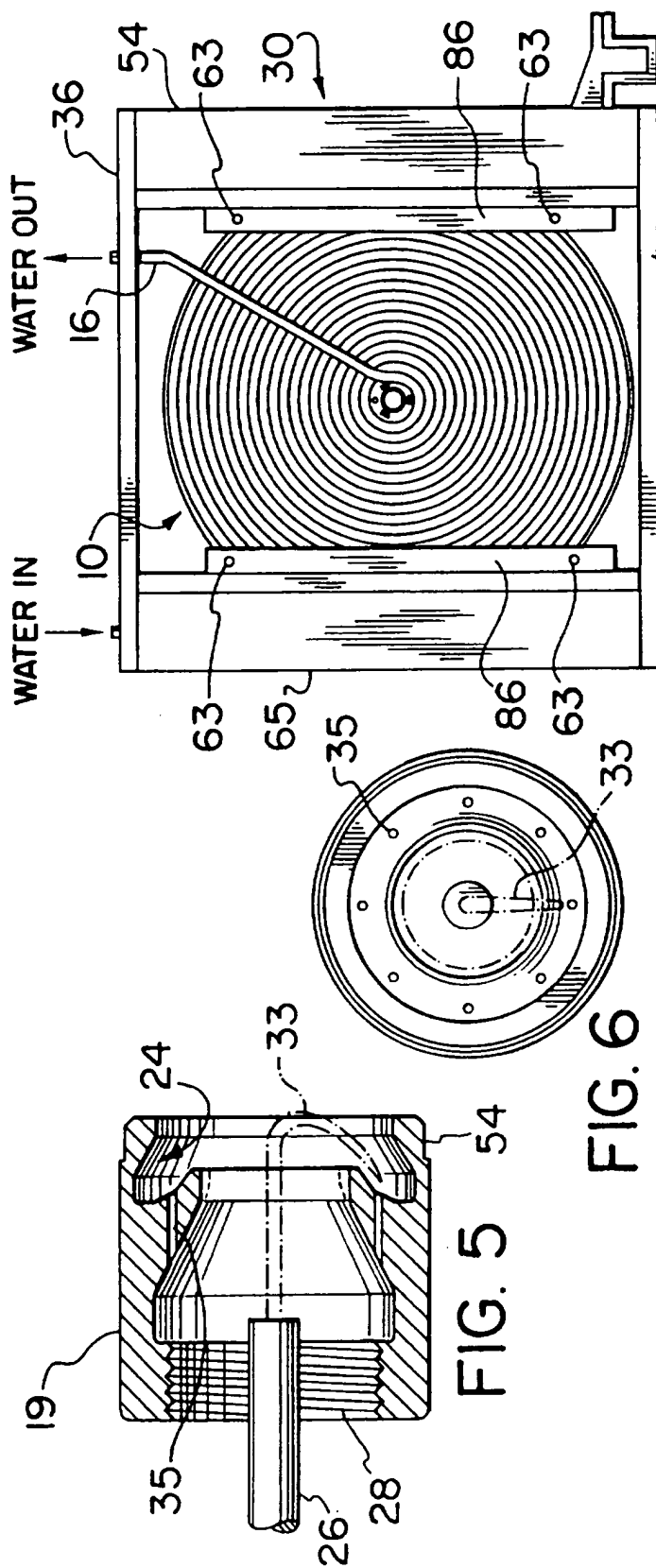


FIG. 5

FIG. 6

FIG. 7

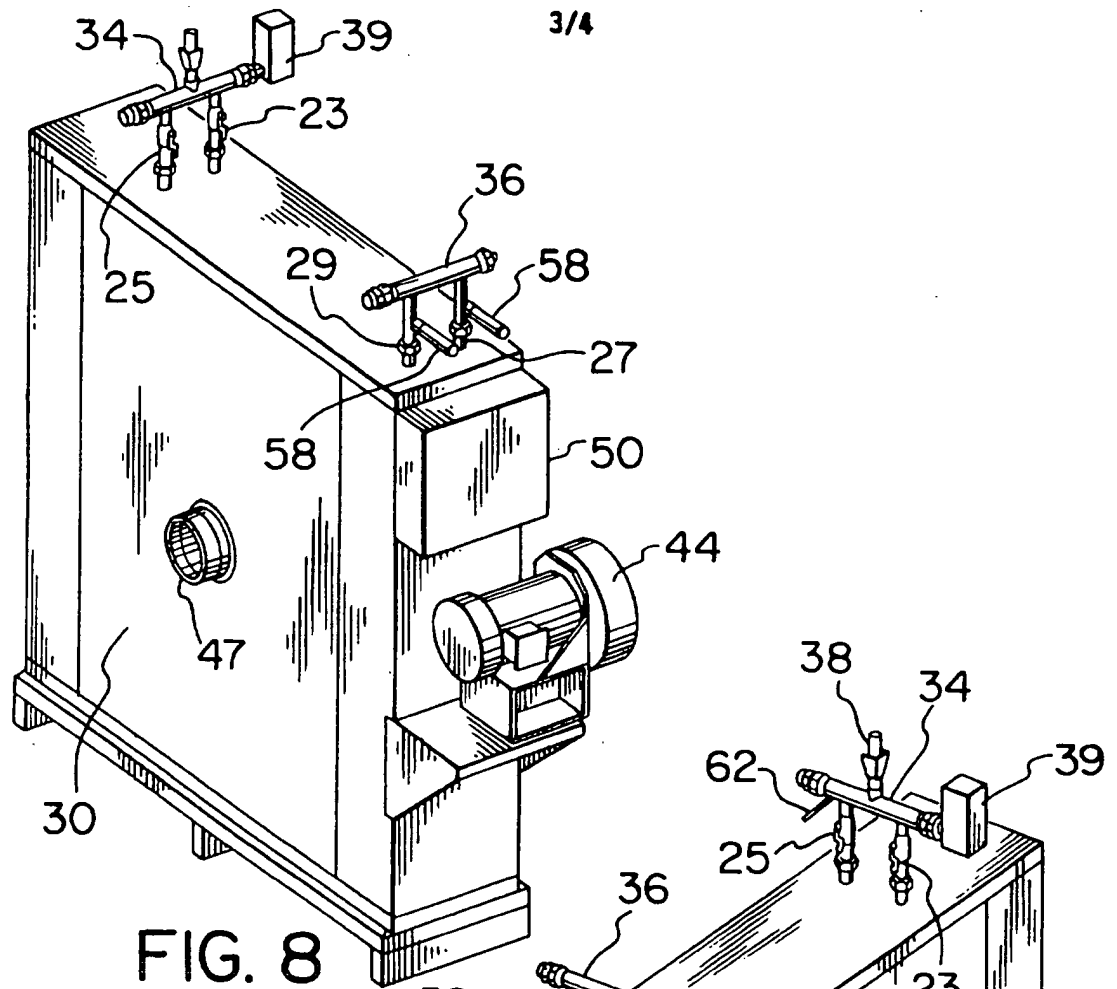


FIG. 8

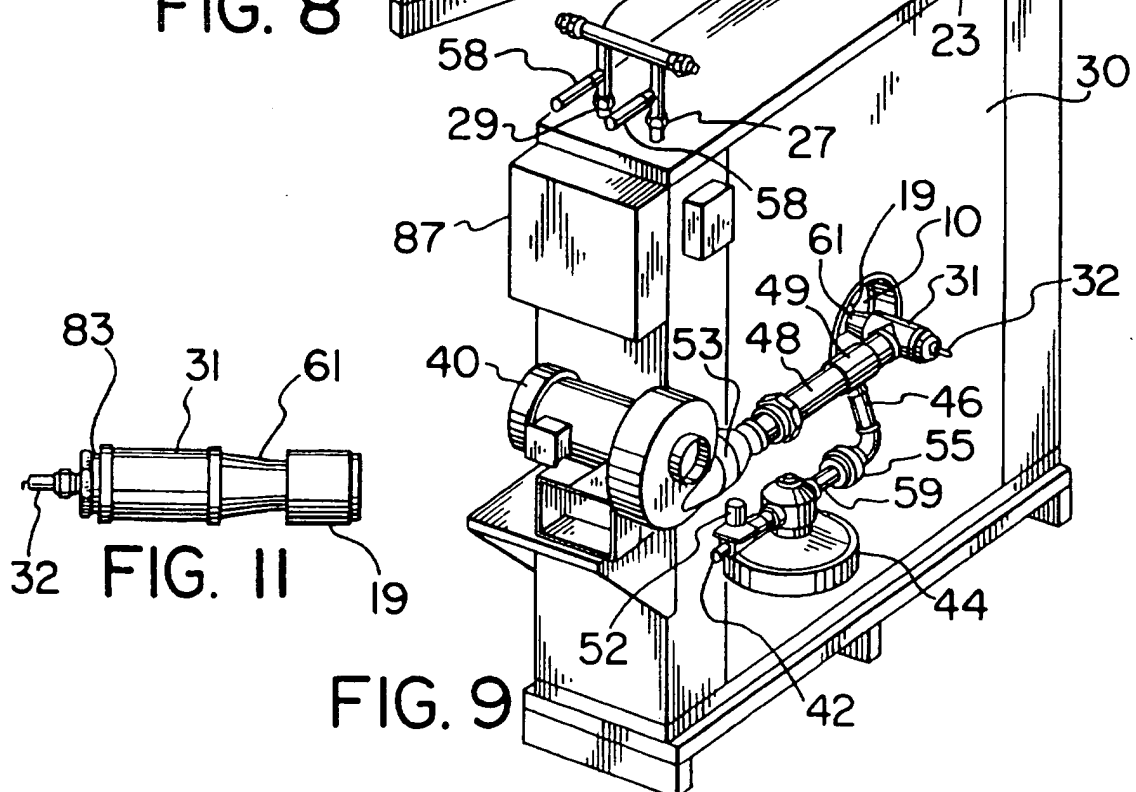


FIG. 9

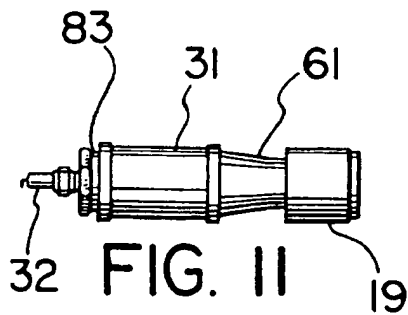
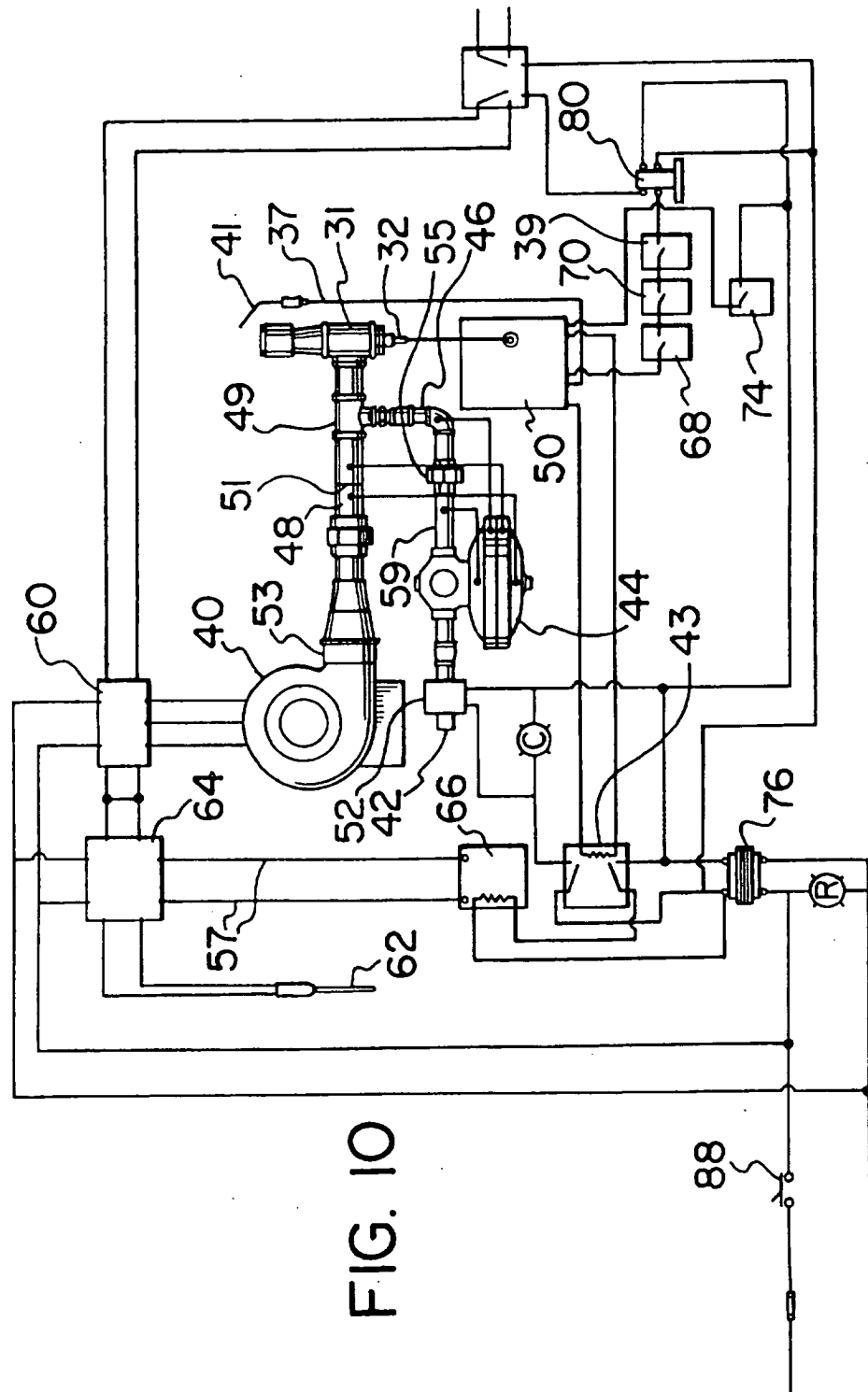


FIG. 11



INTERNATIONAL SEARCH REPORT

International Application No

PCT/CA 96/00136

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F23C11/04 F24H1/43

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 F23C F24H F23M F23N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,4 968 244 (MOVASSAGHI MEHRZAD) 6 November 1990 cited in the application see the whole document ---	1-5
A	FR,A,589 096 (HALLOT) 22 May 1925 see the whole document ---	1,2
X	EP,A,0 317 178 (DAVAIR HEATING) 24 May 1989 see the whole document ---	6-10
X	PATENT ABSTRACTS OF JAPAN vol. 007, no. 183 (M-235), 12 August 1983 & JP,A,58 085016 (MATSUSHITA DENKI SANGYO KK), 21 May 1983, see abstract --- -/--	6,7,10

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

27 September 1996

Date of mailing of the international search report

01.10.96

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INTERNATIONAL SEARCH REPORT

International Application No

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 009, no. 152 (M-391), 27 June 1985 & JP,A,60 029516 (MATSUSHITA DENKI SANGYO KK), 14 February 1985, see abstract ---	6,7,10
X	EP,A,0 532 339 (PALOMA KOGYO KK) 17 March 1993 see the whole document -----	6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CA96/00136

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

CLAIMS (1-5),(11-15) : Pulse combustor provided with water cooled walls each formed of hollow tubing wound in spiral form and boiler wherein the combustor is of the pulsating type.

CLAIMS (6-10) : Boiler wherein a control unit speeds up or slows down on fan which supplies combustion air to a combustor of any kind.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-4968244	06-11-90	CA-A- 1319885	06-07-93
FR-A-589096	22-05-25	NONE	
EP-A-317178	24-05-89	NONE	
EP-A-0532339	17-03-93	JP-A- 5071709	23-03-93
		DE-D- 69210517	13-06-96
		ES-T- 2086668	01-07-96
		US-A- 5220864	22-06-93